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PROGRESS REPORT ON HYDRAULIC AGITATION OF WETTABLE POWDERS[1]

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INTRODUCTION

Spraying wettable powder formulations of agricultural chemicals presents more problems than spraying either emulsions or true solutions. Wettable powders are finely ground solids very similar to clay in particle size and in some other physical properties. Wettable powders, like clay, will settle to the bottom of the suspending liquid unless the particles are kept in motion by adequate agitation. Settling of the powder results in altered concentration of the chemical, clogged strainers, nozzle stoppage, and excessive pump wear. On the other hand, formulation of some chemicals as wettable powders offers a practical solution to problems in economy and chemistry.

If the advantages of wettable powders are to be exploited, the problem of agitation must be solved. Various types of agitators are in current use, but some of these are inadequate and others elaborate and expensive. This report covers a study that was designed to obtain information on attaining adequate agitation with simple and commercially available equipment. Steel 55-gallon oil drums were selected as tanks for this initial study, because they are the predominant tank on tractor-mounted sprayers. A spray system pressure of 30 p.s.i. was used throughout the tests as this is a median of the pressure recommendations for spraying cotton. Although the work involved only a single herbicide, the results should be applicable to similar formulations of other chemicals.

1/ Cooperative investigations of the Agricultural Engineering Research Division and Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Delta Branch, Mississippi Agricultural Experiment Station, Stoneville, Mississippi. The work reported here is part of a contributing project under the Regional Cotton Mechanization Project S-2.

2/ Agricultural Engineer, Agricultural Engineering Research Division, and Agronomist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, respectively.

MATERIALS AND METHODS

Test Equipment

A test stand was designed and equipped to give controlled flows and pressures. Racks on top of the stand held two 55-gallon drums with the long axis in the horizontal position. (Fig. 1.) Liquid flowing to the intake side of the pump came from an outlet on the bottom of each drum. A cutoff valve on each drum controlled flow into a common manifold. Although fluid could be drawn from both tanks, only one was used at a time. Figure 2 shows a schematic diagram of the spraying system used in the tests. The system is essentially the same as that used on most low-volume sprayers on the farm.

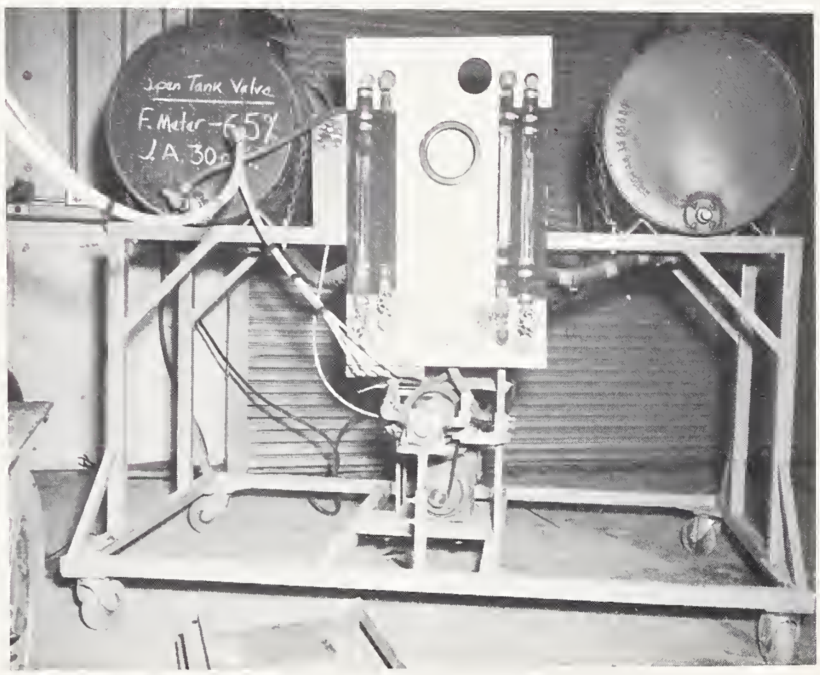

Figure 1. Test stand for hydraulic agitation. Flow was controlled by varying speed of pump. Instrument panel contains variable area flowmeters, pressure gauge, and tachometer. Plastic hoses in foreground lead to spray nozzles.

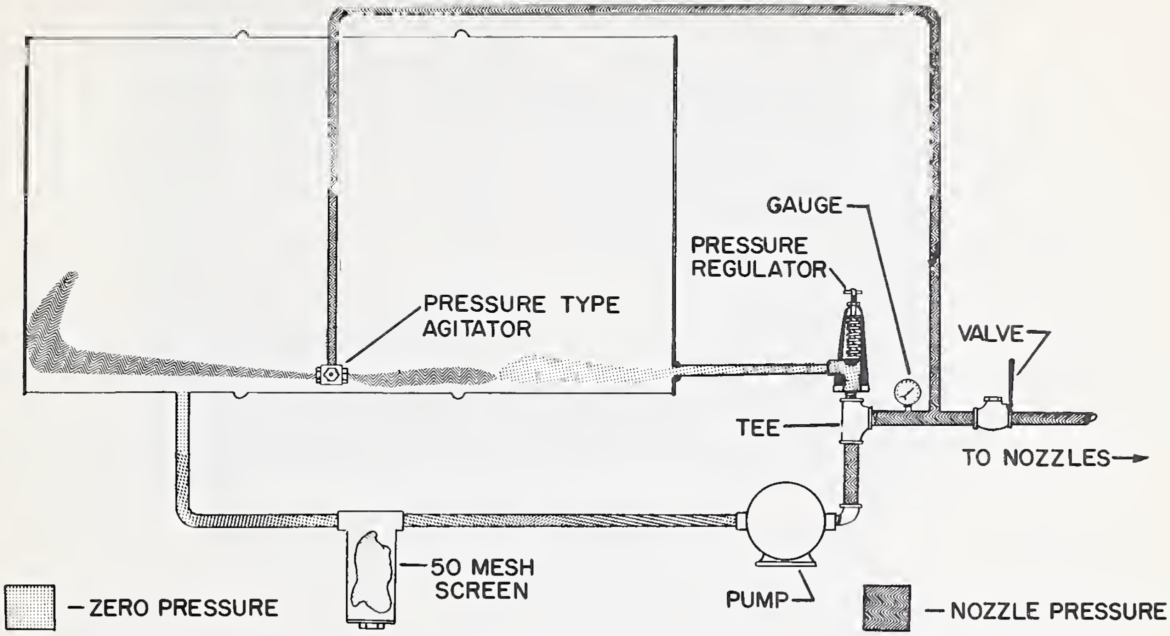

Figure 2. Schematic flow diagram of sprayer showing two types of hydraulic agitation. The pressure device shown and described hereafter operates from the line that supplies the nozzles.

The heart of the system was a pump driven through a speed-change box. By varying the speed, the desired rate of flow and pressure was maintained for individual tests. Variable area flow meters were installed in the lines between the pump and the agitation devices. The meters assured the desired rate of flow during each test.

The pressure side of the system consisted of a pressure regulator, manifold for spray nozzles, nozzle cutoff valve, pressure gauges, and a line to the pressure agitation device.

Agitation Devices and Position in the System

The agitation devices studied were:

A. Nonpressurized devices.

1. Venturi mounted in small bung opening and positioned at bottom of tank. (Fig. 3.)

Figure 3. Pressure agitator on 1/4-inch pipe (right) and venturi attached to fitting in bung opening of drum (left). Outlet hole to pump is between the devices.

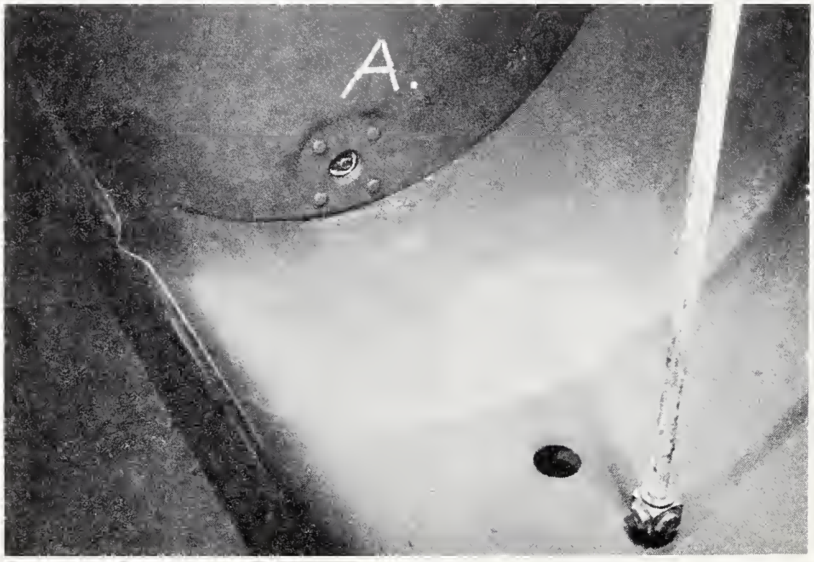

Figure 4. Location of pressure agitator (right) and open discharge in tank (left). Hole in bottom between devices is outlet to the intake side of pump. Pressure device is suspended on 1/4-inch pipe in fixed position approximately one inch from the bottom of the tank.

2. Open discharge consisting of a 5/16-inch opening in the small bung at same height as venturi. (Fig. 4.)

B. Pressurized devices (operated at 30 p.s.i.).

1. Three-outlet cluster with straight-stream orifices positioned as shown in figures 3 and 4.

2. Three-outlet cluster combined with each nonpressurized device. (Figs. 3 and 4.)

The open discharge and venturi, which operated from the pressure relief outlet of the pressure regulator, did not substantially restrict flow. Continuous agitation was provided by the pressure agitator that was installed in the pressure side of the system ahead of the nozzle cutoff valve. This device operated at approximate nozzle pressure.

Wettable Powder Suspension

A commercial formulation of 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea (diuron)[3/] at the rate of 8 pounds of formulation per 100 gallons of water was used in all experiments.

Sampling and Laboratory Techniques

Samples of the herbicide suspension were collected in either one of two ways. While pumping the diuron suspension from the tank through the nozzle orifices, the material was collected in quart jars at the orifices as the liquid level in the tank dropped past the selected 45-, 25-, and 5-gallon levels. Samples of the initial concentrations and samples drawn while merely circulating the liquid through the tank and pump were obtained by dipping quart jars into the top 3 or 4 inches of the liquid. Approximately one quart of material was obtained from each of two nozzles or each of two locations in the tank; and the two samples composited as one sample. Subsamples of equal volume were filtered, dried, and weighed to determine the content of the wettable powder. All samples collected in one experiment were assayed simultaneously, and in duplicate. Assays were repeated when differences between duplicates exceeded three percent.

3/ Sold as "Karmex" containing 80 percent diuron. The mention of trade products does not imply that they are recommended or endorsed by the Department of Agriculture over similar products of other companies not mentioned.
Trade names are used here for convenience in reference only.

RESULTS AND DISCUSSION

No Agitation

The concentration of herbicide caught from the spray nozzles with no agitation is shown in figure 5a. The effects of spraying diuron with agitation after a thoroughly mixed tank was allowed to settle for two hours is shown in figure 5b. The time consumed in spraying the liquid from each tank was 16 minutes. This emphasized the rapid fallout from suspension with this material.

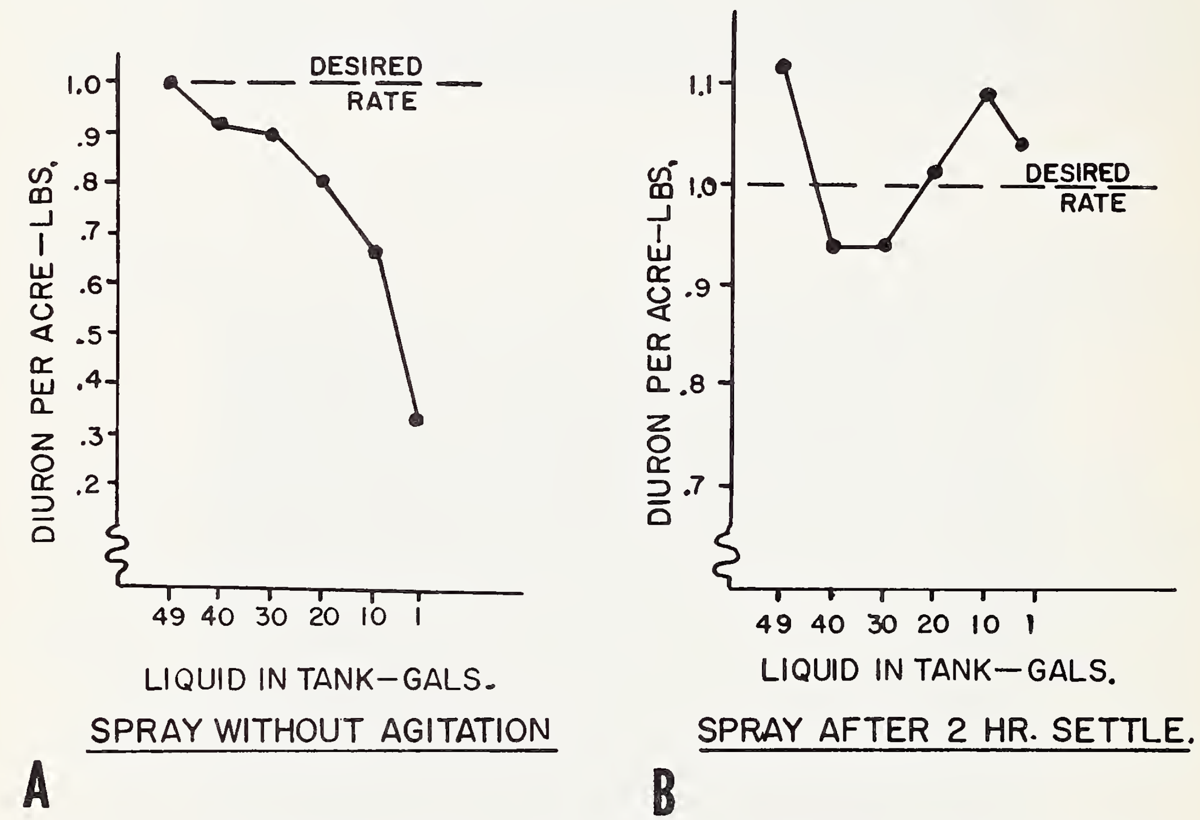

Figure 5. Results of spraying well-mixed herbicide (A) with agitation -- spraying initiated immediately after mixing, (B) with agitation -- agitation and spraying initiated after a two-hour settling period.

Releasing the bypass liquid at the top of the tank produced essentially the same results as no agitation. (Fig. 5a.)

The attachment of the agitation devices to hoses and dropping them into the tank was ruled out of the tests. Agitation variation caused by random position of agitation devices was obtained when the agitation devices were simply attached to the hoses and dropped into the tank.

Nonpressure Agitation

Creasy and Wilson[4/] showed that hydraulic agitation is feasible with wettable powders and the necessary power requirements.

A severe method was designed to evaluate the devices used in the test. First, the material was thoroughly mixed in the afternoon, then the suspension was allowed to settle overnight. Samples drawn from the top of the tank the next morning indicated that only one to three percent of the material had remained in suspension. The other 99 to 97 percent of the solid material was settled in the bottom of the tank.

The test stand was started and samples were drawn from the top of the tank at timed intervals.

The venturi and open discharge methods were compared with six and five gallons per minute being returned to the tank. There was no substantial difference in the resuspension ability of the venturi as compared to the open discharge at the same flow rates. Both devices produced satisfactory resuspension after 10 minutes running time with 6 g.p.m. being returned. Neither device was considered satisfactory at 5 g.p.m. with 10 minutes running time. These procedures may not be practical for resuspension under field conditions because of the running time required for satisfactory resuspension.

Combination Pressure and Nonpressure Agitation

This test combined the pressure device with the nonpressure devices. The orifices used with the pressure device had a combined rating of 1.4 g.p.m. at 30 p.s.i. (Orifice 1/16-inch). The input to the nonpressure devices was adjusted to bring the total agitation flow to 6 and 5 g.p.m.

4/ Creasy, L. E. and Wilson, C. E., Jr., Equipment factors affecting the application of wettable powder formulations of substituted urea herbicides. Unpublished mimeographed report by the E. I. du Pont de Nemours and Company - 1952.

The same resuspension test as that used with the nonpressure devices was conducted. The combination of the open discharge and pressure device did not produce as good agitation as the open discharge alone. The combination of the venturi and pressure device was not so good as the venturi alone.

Pressure Agitation

The poor results obtained with combinations of pressure and nonpressure devices indicated the need for increased flow through the pressure device. For the remaining studies orifice sizes were increased from a flow of 1.4 g.p.m. to 2.8 and 3.36 g.p.m. The venturi was used as a check at the flow rate of 2.8 g.p.m. The three agitation methods were subjected to the resuspension test.

The pressure device at 2.8 g.p.m. was significantly better than the venturi at 2.8 g.p.m. Furthermore, the pressure device at 3.36 g.p.m. was better than the same device at 2.8 g.p.m. Agitation results at 3.36 g.p.m. (Orifice 5/64-inch) were considered excellent, even with as little as five minutes running time.

These results were checked against another type of test. The materials were mixed and then agitated by each of the three methods for 20 minutes. Samples were drawn from the top of tank at the beginning and end of each run. Results from this test were in the same order as those obtained in the resuspension test.

CONCLUSIONS

The conclusions based on results of the tests are as follows:

1. Fallout of material is surprisingly fast. Before starting the sprayer, all of the material should be in suspension.

2. No substantial gain in agitation was obtained with a venturi as compared with an open discharge.

3. A pressure agitation device with three straight-stream orifices (drill size, 1/16-inch) delivering 1.4 g.p.m. did not give adequate agitation. Within the rates of flow used in this part of the study the nonpressure devices alone produced better agitation than a combination of pressure and nonpressure devices at the same total rate of flow.

4. A pressure device with larger orifices (drill size, 5/64-inch) delivering 3.36 g.p.m. did give adequate agitation. This device was suspended on a rigid pipe in the center of the drum with the orifices approximately 1-inch from the bottom of the tank. The best agitation in the study was obtained with this device.

5. A pressure agitator operates from the same line that supplies the nozzle tips; therefore, it can serve as an automatic safeguard against undetected pump deterioration. Pump wear, which renders the pump incapable of supplying enough liquid for nozzles and agitation, will be indicated immediately because of its inability to maintain desired spraying pressure.

6. With pressure agitation, the primary function of the surplus flow from the relief outlet of the pressure regulator is to provide pressure regulation. Nevertheless a certain amount of extra agitation can be obtained by releasing the bypass flow at the bottom of the tank.

7. A pump that will deliver a minimum of 10 g.p.m. will adequately supply the spray nozzles and the pressure agitator and will have a surplus to maintain desired nozzle pressure for a 4-row, 55-gallon spray rig spraying up to 40 gallons per acre at 5 miles per hour.

ROUTINE MAINTENANCE OF SPRAYERS USING WETTABLE POWDERS

Correct operation and maintenance are necessary for satisfactory results with the best equipment, and satisfactory results may often be obtained with equipment that is limited in quality.

Only the best devices produced satisfactory resuspension of material from the bottom of the tank. Many of the devices, however, were able to keep a mixture stirred once it had been put into a uniform suspension.

As a safety precaution, a wettable powder should be suspended (no solid material on the bottom) and thoroughly mixed manually with a metal paddle or other similar device prior to spraying any of the mixture. This should be done immediately before starting the pump and agitation system. Once the desired suspension has been obtained, agitation should not be stopped until the spraying operation is finished. If stoppage cannot be avoided, the initial manual stirring should be repeated before restarting the spraying operation. Failure to maintain a uniform mixture at all times while spraying can result in both over- and under-application of the powder.

Manual stirring and inspection of the mixtures requires a large filler opening at the top of the tank. The opening should be large enough to permit insertion of hands and tools into all parts of the tank for cleaning, inspecting, and stirring purposes. Figure 6 shows a steel paddle being dragged across the tank bottom. Wooden paddles produce splinters that cause screen and nozzle stoppage.

Figure 6. Steel paddle for stirring wettable powders. Wooden paddles cause nozzle stoppage from splinters. Blade is sheetmetal with the bottom rounded to fit curvature of drum bottom. Handle is 1/2-inch pipe brazed or welded to blade. Most of the material settles across an area one foot wide. It is important to drag blade over this area.

At the end of each day of spraying the tank should be completely drained and all nozzle strainers removed and cleaned. Clean water should be pumped through the system prior to replacing nozzles and strainers. This procedure will help to prevent the buildup of over-strength solutions and sprayer-damaging trash.

When a fresh mixture is made, any spray material remaining in a tank should be removed. This remaining material can be stored in a 55-gallon drum until a full tank load has accumulated. It may then be treated as a fresh load and used. The continual addition of fresh spray material to fractional tanks of old material can lead to incorrect concentrations, since this procedure would cause an accumulation of errors which individually might be insignificant.

ACKNOWLEDGMENTS

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